

# **INDOOR AIR QUALITY ASSESSMENT**

**Mildred Elly Business School  
505 East Street  
Pittsfield, Massachusetts**



Prepared by:  
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Center for Environmental Health  
Bureau of Environmental Health Assessment  
Emergency Response/Indoor Air Quality Program  
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## **Background/Introduction**

In response to a request from Mr. Steve D'Angelo, Senior Sanitarian, Pittsfield Health Department, an indoor air quality assessment was done at the Mildred Elly Business School (MEBS), 505 East Street, Pittsfield, Massachusetts. This assessment was conducted by the Massachusetts Department of Public Health (MDPH), Center for Environmental Health (CEH), Bureau of Environmental Health Assessment (BEHA). Complaints from employees concerning symptoms believed to be attributed to poor air quality conditions in the building, as well as odors from a nearby auto body shop prompted the request.

A visit was made to the building by Michael Feeney, Director of Emergency Response/Indoor Air Quality (ER/IAQ), BEHA on May 12, 2004. Mr. Feeney was accompanied by Mr. D'Angelo during the visit. The MEBS is an adult education school located in a renovated building in a mall development that was formerly a grocery store. The MEBS moved into this location in 1995. The first floor is subdivided into multiple tenant spaces that surround a central atrium with a fountain. These spaces include the MEBS, as well as a dentist office and a vacant office. The MEBS occupies both the ground floor, and the aforementioned first floor consisting of the business office, legal library and classrooms. The ground floor of the MEBS consists of classrooms, a kitchen, administrative offices and a privately owned judo studio. The facility has no openable windows. The indoor air quality assessment at the MEBS conducted by BEHA was limited to leased/accessible spaces. Other business spaces within the complex were not examined.

## **Methods**

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID).

## **Results**

The MEBS has a population of approximately 48 employees and 130 students. The tests were taken under normal operating conditions. Test results appear in Table 1.

## **Discussion**

### **Ventilation**

It can be seen from table 1 that carbon dioxide levels were above 800 parts per million (ppm) in all but one area surveyed in the MEBS as well as the central atrium area (Table 1) demonstrating an inadequate fresh air supply. It is important to note that some carbon dioxide levels measured above 800 ppm were in unoccupied areas, which further indicates inadequate air exchange.

Ventilation is provided by a separate heating, ventilation and air-conditioning (HVAC) system on each floor. The first floor air handling unit (AHU) could not be accessed during the assessment. Ventilation on the first floor of the building appeared to be provided by a rooftop AHU that distributes fresh air through ducted ceiling diffusers. Ventilation is provided on the ground floor by an AHU located in a mechanical room

(Picture 1). Fresh air is drawn through a vent in the rear exterior wall of the building (Picture 2) and ducted to fresh air diffusers.

Return ventilation is dependent on the ceiling plenum (i.e., the space above the ceiling tile system). There is no ductwork in this type of system; air is drawn directly into the ceiling plenum and is returned to the AHUs. Holes are cut into interior walls above the ceiling tile system to allow airflow from classrooms back to the AHU (Picture 3). While return ventilation exists in classrooms, no means to exhaust air through the general ventilation system could be identified. With a lack of exhaust ventilation, existing pollutants inside the building are not removed and are continuously recirculated, which can lead to air quality/comfort complaints. This condition is significant with regard to odor complaints within this facility.

In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air. It is recommended that HVAC systems be re-balanced every five years (SMACNA, 1994). The mechanical ventilation system, in its current condition (no exhaust ventilation), cannot be balanced.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997, BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see [Appendix A](#).

Temperature readings ranged from 72° to 78° F, which were within the BEHA recommended guidelines. The BEHA recommends that indoor air temperatures be maintained in a range of 70° to 78° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

Relative humidity measurements ranged from 35 to 44 percent, which were close to the BEHA recommended comfort range. The BEHA recommends a comfort range of

40 to 60 percent for indoor air relative humidity. Relative humidity would be expected to drop below comfort levels during the heating season. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

### **Microbial Growth/Moisture Concern**

A number of water damaged ceiling tiles were observed in the general classroom area on the first floor, which can indicate leaks from the roof or plumbing system. Water-damaged porous building materials can provide a source for mold and should be replaced after a water leak is discovered and repaired. The US Environmental Protection Agency and the American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If they are not dried within this time frame, mold growth may occur. Water-damaged ceiling tiles cannot be adequately cleaned to remove mold growth. The application of a mildewcide to moldy ceiling tiles is not recommended. Fungal growth begins once water soaks porous materials. The fungus grows through its lifecycle to produce spores. Some spores are extremely buoyant and can be drawn into the ceiling plenum by operation of the ventilation system.

Plants were observed in several areas. Plants, soil and drip pans can serve as sources of mold growth. Plants should be properly maintained, over-watering of plants should be avoided and drip pans should be inspected periodically for mold growth. Plant

pots should not be in direct contact with carpeting in order to prevent moistening of carpet materials.

### **Other Concerns**

As noted in the ventilation section of this assessment, the lack of an exhaust component to the HVAC system can allow for normally occurring pollutants to accumulate (waste heat, water vapor, emissions from photocopiers, etc.). If an outdoor pollutant were introduced into the building, it would likely accumulate/linger without a means to remove it from the indoor environment. As noted, occupants reported odors of solvent/paint believed to be attributed to an auto body shop located east, behind the building across Whipple Street (Picture 4). Mr. D'Angelo reported that the auto body facility was visited by the Massachusetts Department of Environmental Protection (MDEP) (personal communication with Steve D'Angelo, Pittsfield Health Department, 2004). Mr. D'Angelo reported that the auto body shop was planning to extend the height of its spray booth stack. While the auto body shop may play some role in odors reported in the MEBS, a number of factors indicate that other sources of pollutants may exist within the building:

- The fresh air intake for the ground floor AHU is located approximately 6 feet above the ground. The terminus for the exhaust stack for the auto body shop is located over twenty feet above street level. The difference in height would tend to limit the amount of paint vapors at or near ground level.
- Except under unusual weather conditions, prevailing winds in Massachusetts tend to be from the west. As an example, moist weather tends to travel in a

northeasterly track up the Atlantic Coast towards New England (Trewartha, G.T., 1943). Wet weather systems generally produce south/southwesterly winds, whereas winter winds tend to be northwesterly. Since the auto body shop is located east of the MEBS, the pollutants from the stack generally would be blown away from the building. May 12, 2004 (the day of the MDPH assessment) was a sunny, cloudless day, with winds blowing from the northwest, parallel to the MEBS rear wall.

- A potential source of pollutants that is likely entrained by the HVAC system is the exhaust vent for the ground floor AHU gas burner. This exhaust vent is located in the rear wall of the MEBS at the same level as the AHU fresh air intake. If the gas burner were activated on the day of the assessment, the wind direction noted would carry products of combustion toward the fresh air intake, creating the opportunity for entrainment. The process of combustion produces a number of pollutants; however, the pollutant produced is dependent on the material combusted. Common combustion emissions include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). In the experience of BEHA staff, combustion product emissions can be described as having a “chemical-like” odor. Outdoor carbon monoxide concentrations were non-detect or ND. Carbon monoxide levels measured in the MEBS were also ND (Table 1).
- As reported by MEBS administrative staff, it is believed that a business within the structure engages in wood staining. Wood stains consist of a number of ingredients, including volatile organic compounds (VOCs). In addition, a dental



office is also located on the first floor. Denture labs use a number of VOC-containing materials, including methyl methacrylate as part of the production of dental prosthesis. VOCs are carbon-containing substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose and/or respiratory irritation in some sensitive individuals. Chemicals evaporating from stained wood at room temperature and/or materials used during the production of dental prosthesis likely contain VOCs. Businesses that use VOC-containing compounds should have dedicated exhaust ventilation systems to remove chemicals and odors from the building. If no such system exists, evaporating VOCs can be drawn into the general HVAC system and distributed to other areas of the building.

In an effort to determine whether VOCs were present inside the building, air monitoring for TVOCs was conducted. Outdoor measurements were taken for comparison. Outdoor TVOC concentrations were ND. TVOC concentrations were low but detectable within the MEBS (Table 1). Of note were the TVOC measurements on the first floor, in offices with doors that open into the stairwell leading to the ground floor. The source of VOCs was traced to a door at the base of the stairwell that leads to a judo studio. TVOCs were measured around the doorframe of the judo studio. Since heated air rises, air from the base of the stairwell would rise to the top of the stairwell, where it would pool and be drawn into MEBS offices by the operation of the HVAC system. As discussed BEHA staff *only* examined MEBS areas for potential respiratory irritants, therefore the source of VOCs in the judo studio could not be identified as part of the assessment.

A number of classrooms in the MEBS contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat.

Several other conditions, which can affect indoor air quality, were noted during the assessment. In order to provide efficient combustion for the gas jet in the AHU, an adequate supply of combustion air is needed to provide oxygen. A combustion air vent is usually located in an area near this equipment. No make up air vent or ductwork that would provide combustion air could be identified. Without the introduction of air from the outside, air is drawn from the mechanical room and ultimately, from the ground floor area. In addition, the lack of oxygen may result in the production of incomplete combustion products, such as carbon monoxide. As previously mentioned, no measurable levels of carbon monoxide were detected during the assessment, however these results would be expected in a building with the AHU heating system *deactivated*. The presence of combustion products indoor may differ when the AHU system is *reactivated* in during the heating season.

AHUs are normally equipped with filters that strain particulates from airflow. Filters installed in the fresh air intake of the ground floor AHU provide minimal filtration (5 % dust spot efficiency at best). In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40 percent would be sufficient to

reduce airborne particulates (Thornburg, D., 2000; MEHRC, 1997; ASHRAE, 1992).

Note that increased filtration can reduce airflow produced by AHUs due to increased resistance (called pressure drop). Prior to any increase of filtration, all AHUs should be evaluated by a ventilation engineer to ascertain whether they can maintain function with more efficient filters.

## **Conclusions/Recommendations**

In view of these findings at the time of the visit, the following recommendations are made:

1. Install a wall-mounted carbon monoxide monitor with digital readout near the gas-fired AHU. Carbon monoxide levels should be checked daily after the AHU is fired up during the heating season.
2. Contact an HVAC engineering firm and/or consult with the local fire prevention officer/building code officials to determine an appropriate method to provide combustion air for the AHU. A ducted mechanical fan may be necessary to introduce more fresh air. If not feasible, consider replacing the current AHU with an electric model.
3. Extend the exhaust vent for the ground floor AHU at least 10 feet above the level of the fresh air intake vent.
4. Conduct a building wide evaluation to determine whether business use or have processes that produce TVOCs that can be entrained by the general ventilation system. Either provide appropriate dedicated exhaust ventilation for TVOC using/producing activities, or consider prohibiting these activities.

5. Consider rendering the ground floor mechanical room as airtight as possible to eliminate the draw of combustion air from occupied areas. These measures would include:
  - a. installing a boiler room style, fire rated door in the mechanical room portal;
  - b. installing weather-stripping along the doorframe of the mechanical room door;
  - c. installing a door sweep at the bottom of the door of the mechanical room door;
  - and
  - d. sealing the spaces around utility pipes within the mechanical room.
6. Ventilation industrial standards recommend that mechanical ventilation systems be balanced every five years (SMACNA, 1994). Consult a ventilation engineer concerning re-balancing of this ventilation systems.
7. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations). Consider obtaining a vacuum cleaner equipped with a high efficiency particulate arrestance (HEPA) filter to trap respirable dusts.
8. Ensure leaks are repaired and replace water damaged ceiling tiles. Examine the area above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.

9.        Avoid over-watering plants and examine drip pans periodically for mold growth. Disinfect with an appropriate antimicrobial where necessary. Consider reducing the number of plants in some areas.
10.      Examine the feasibility of increasing HVAC filter efficiency. Ensure that filters are of a proper size and installed in a manner to eliminate particle bypass of the filter. Note that prior to any increase of filtration, each unit should be evaluated by a ventilation engineer as to whether they can maintain function with more efficient filters.

## References

- ACGIH. 1989. Guidelines for the Assessment of Bioaerosols in the Indoor Environment. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.
- ASHRAE. 1992. Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter. American Society of Heating, Refrigeration and Air Conditioning Engineers. ANSI/ASHRAE 52.1-1992.
- BOCA. 1993. The BOCA National Mechanical Code-1993. 8<sup>th</sup> ed. Building Officials & Code Administrators International, Inc., Country Club Hills, IL. M-308.1
- MEHRC. 1997. Indoor Air Quality for HVAC Operators & Contractors Workbook. MidAtlantic Environmental Hygiene Resource Center, Philadelphia, PA.
- OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.
- Sanford. 1999. Material Safety Data Sheet (MSDS No: 198-17). Expo® Dry Erase Markers Bullet, Chisel, and Ultra Fine Tip. Sanford Corporation. Bellwood, IL.
- SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0
- SMACNA. 1994. HVAC Systems Commissioning Manual. 1<sup>st</sup> ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, WV.
- Thornburg, D. 2000. Filter Selection: a Standard Solution. *Engineering Systems* 17:6 pp. 74-80.
- Trewartha, G.T. 1943. *An Introduction to Weather and Climate*. McGraw-Hill Book Company, New York, NY.
- US EPA. 2001. Mold Remediation in Schools and Commercial Buildings. US Environmental Protection Agency, Office of Air and Radiation, Indoor Environments Division, Washington, D.C. EPA 402-K-01-001. March 2001.

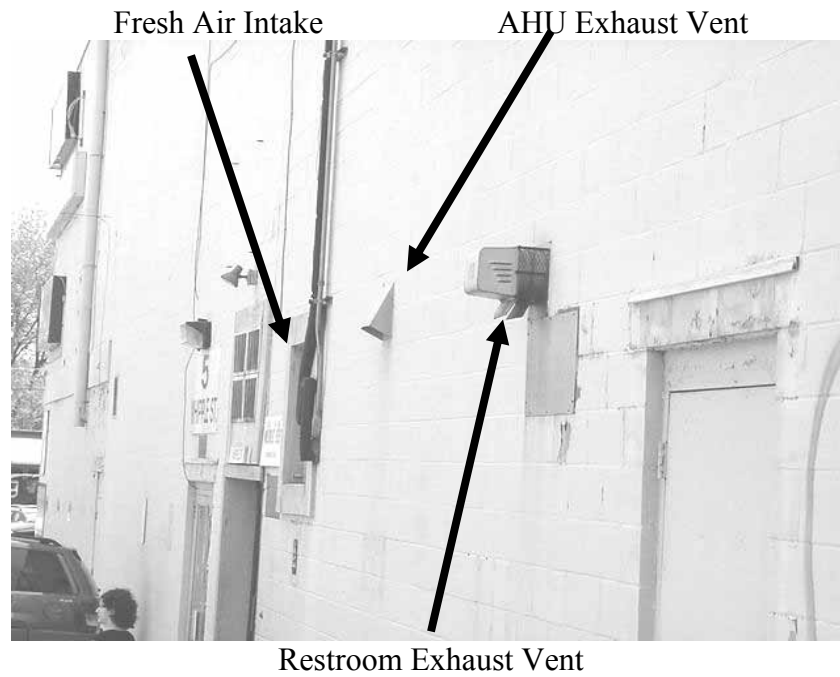
**Picture 1**

Combustion Air Intake of AHU



**AHU in Mechanical Room on Ground Floor**

**Picture 2**



**Fresh Air Supply Vent, AHU Exhaust Vent and Restroom Exhaust Vent on Rear Wall of MEBS Building**



**Picture 3**



**Hole in Interior Wall on Ground Floor in Ceiling Plenum**

**Picture 4**



**Auto Body Shop Located East of the MEBS Building, Note Exhaust Stack**

**TABLE 1****Indoor Air Test Results – Mildred Elly Business School****May 12, 2004**

Remarks	Carbon Dioxide (*ppm)	TVOC (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
							Supply	Exhaust	
Outside at rear door of building, street level	389	ND	83	42	-	-	-	-	Sunny, moderate wind from northwest
Outside at property line of autobody shop	383	ND	83	42	-	-	-	-	
Outside front door at parking lot level	391	ND	78	45	-	-	-	-	
Atrium	677	0.9	76	42	0	N	Y	Y	Fountain in lobby
President's office	1398	0.8	75	40	1	N	Y	Y	
Meeting Room Admin. Office	1341	0.9	74	41	0	N	Y	Y	
Main Office	1313	0.9	74	40	2	N	Y	Y	Plants Photocopier
Massage therapy	920	0.4	75	35	1	N	Y	Y	Candles Essential oils
Break area off atrium	705	0.2	76	42	3	N	Y	Y	2 soda vending machines 2 microwave ovens
Tech Lab 1	851	0.4	77	40	0	N	Y	Y	Dry erase marker boards

\* ppm = parts per million parts of air

**Comfort Guidelines**

Carbon Dioxide - < 600 ppm = preferred  
600 - 800 ppm = acceptable  
> 800 ppm = indicative of ventilation problems

Temperature - 70 - 78 °F  
Relative Humidity - 40 - 60%

**TABLE 1**

**Indoor Air Test Results – Mildred Elly Business School**

**May 12, 2004**

Remarks	Carbon Dioxide (*ppm)	TVOC (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
							Supply	Exhaust	
Therapy 1	953	0.1	73	35	0	N	Y	Y	Dry erase marker boards
Therapy 2	1036	0.3	73	36	0	N	Y	Y	Dry erase marker boards
Tech lab 2	979	0.3	78	41	0	N	Y	Y	Dry erase marker boards
Med Lab 1	890	0.3	78	39	0	N	Y	Y	
Legal Research	832	0.4	76	42	0	N	Y	Y	
Accounting	1634	0.5	77	41	6	N	Y	Y	
Ground Floor Administration Office	1196	0.1	76	41	5	N	Y	Y	Photocopier
1	1082	0.1	74	41	0	N	Y	Y	Dry erase marker boards
2	1043	ND	75	42	1	N	Y	Y	Dry erase marker boards
3	1154	ND	75	42	7	N	Y	Y	Dry erase marker boards Plants

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Remarks	Carbon Dioxide (*ppm)	TVOC (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
							Supply	Exhaust	
4	1073	ND	74	42	5	N	Y	Y	Dry erase marker boards
5	1128	ND	73	42	1	N	Y	Y	Dry erase marker boards
6	1018	ND	73	42	2	N	Y	Y	Dry erase marker boards
7	1130	ND	72	44	12	N	Y	Y	Dry erase marker boards
Base of stairwell to judo studio, ground floor		0.6							

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